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Chromosome numbers in the genus *Formica* with special reference to the taxonomical position of *Formica uralensis* Ruzsk. and *Formica truncorum* Fabr.

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The chromosome numbers of the species *Formica aquilonia* Yarr., *Formica uralensis* Ruzsk. and *Formica pressilabris* Nyl. were all found to be n=26. The chromosome number of *F. uralensis* thus does not accord with the view that this species belongs to be subgenus *Serviformica*. Chromosomal polymorphism was found in *Formica truncorum* Fabr., one population having the haploid number n=28, instead of n=26. The chromosome numbers obtained for South Finnish populations of *Formica polyctena* Foerst., *Formica pratensis* Retz., *Formica lugubris* Zett., *Formica rufibarbis* Fabr. and *Formica transkaucasica* Nas. were the same as those reported from Central Europe.

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The systematics of the genus *Formica* is still unclear, especially with respect to *Formica* sensu stricto (= the "*rufa* group" as defined by BETREM 1960). Not only are the morphological criteria commonly used in delimiting species within the subgenus *Formica* rather vague but the same species may be included in the subgenus or not, or arbitrarily given the status of a "true" member of the *rufa* group or not. A case in point is the mound-building species *Formica uralensis* Ruzsk. This species is usually considered a member of the subgenus *Formica* s.str. or the *rufa* group (BETREM 1960; GÖSSWALD et al. 1965; KUTTER 1977), but DLUSSKY (1967, and personal communication) includes it in the subgenus *Serviformica* (the "*fusca* group"). Another unclear case is represented by *Formica truncorum* Fabr., which is included in the *rufa* group by BETREM (1960) and KUTTER (1977), but not by COLLINGWOOD (1979). Various problems of the *rufa*-group taxonomy can be tackled successfully by unconventional methods: gel electrophoresis of enzymes (PAMILO et al. 1979), analysis of volatile compounds (BERGSTRÖM and LÖFQVIST 1973), application of numerical taxonomy (DOUWES 1979) and use of behavioural critera (ROSENGREN and CHERIX 1980). Chromosomal studies should naturally have a central position in this context. The haploid chromosome number of ants varies between n=3 and n=84, with a genus frequency peak at 14 (CROZIER 1975). A high degree of variability in chromosome number may occur within a single genus (e.g. the genus *Camponotus* with haploid numbers varying between 9 and 26), but within the genus *Formica* the chromosome numbers appear to be very uniform (CROZIER 1975), and the information given by it is, consequently, of limited value, unless complemented by studies of the karyotype. Unfortunately, karyotype analyses are very difficult in *Formica* due to the extreme smallness of the chromosomes. Our intention was to use banding techniques, but the methods we tried did not give satisfactory results.

The chromosome numbers of the species *Formica aquilonia* Yarr., *Formica uralensis* Ruzsk. and *Formica pressilabris* Nyl. are reported here together with that of a possible new *Formica* species described by COLLINGWOOD (1979, p. 152) under the name *Formica* "*nylanderi*". Chromosomal polymorphism occurs in many ant species (CROZIER 1975; IMAI et al. 1977), but has so far not been observed in the genus *Formica*. We have now found chromosomal polymorphism in *Formica truncorum* Fabr. In other cases, however, (*Formica polyctena* Foerst., *Formica pratensis* Retz., *Formica lugubris* Zett., and *Formica transkaucasica* Nas.) the chromosome counts made by

us on Finnish populations are in close agreement with the chromosome numbers previously reported for Central European populations of the same species by HAUSCHTECK-JUNGEN and JUNGEN (1976).

Material and methods

All the chromosome numbers reported in this paper were counted on haploid cells of the testes, although the brains of workers and males were also studied in many of the species. Mitotic divisions in brain cells were, as a rule, found in prepupae, but not in pupae, as was also observed by IMAI (1966) while meiotic figures in the testes were observed mainly in early pupae (the eyes unpigmented or only weakly pigmented). In addition to cells with haploid numbers the testes contained some diploid and polyploid nuclei (e.g. triploid).

The material was dissected in colchicine-hypotonic solution and in most cases incubated for about 20 min in the same solution (see IMAI et al. 1977 for procedure). We used exclusively the air-drying technique described by IMAI et al. (1977). The preparations were checked in the phase contrast microscope and stained in Giemsa solution diluted 1:24 with Sörensen's pH 6.8 buffer. Mounts were prepared with cover slips and neutral mounting medium (Gurr). According to IMAI et al. (1977) this technique should give C-banding without subsequent treatment, but we were unable to obtain satisfactory C-banding, though replacement of incubation in colchicine solution with incubation in pure water appeared to give slightly better results. Attempts to induce G-or C-banding with trypsin or barium hydroxide also failed.

Our material of *Formica* species was collected along the coast of Southern Finland from Sibbo east of Helsinki to the Hitis archipelago west of Hangö (for locality of each of the nests, see Table 1.). The species were determined with the aid of widely used identification guides (e.g. DLUSSKY and PISARSKI 1971; KUTTER 1977). In addition, workers from each nest were investigated in the scanning electron microscope (ISM-U3) at 13 KW, after coating with gold.

Results and discussion

All *Formica* species investigated, except *F. rufibarbis* and the Hitis nest of *F. truncorum* had the haploid number n=26 (Table 1). The material of *F. rufibarbis* was too small and the chromosome number too variable (n=25–28) to permit any definite conclusion, but n=27 was the most common haploid number for this species and corresponds to the diploid number 2n=54 previously reported for *F. rufibarbis* and five other European *Serviformica* species by HAUSCHTECK-JUNGEN and JUNGEN (1976). The number 27 seems to be the rule for the haploid set, having been reported for Nearctic and Asian *Serviformica* as well (HUNG and IMAI, cited in CROZIER 1975; cf. FRANCOEUR 1973). The only known exception is *F. transkaucasica* (synonyme: *F. picea* Nyl.), for which HAUSCHTECK-JUNGEN and JUNGEN (1976) obtained 2n=52 in Switzerland (brain tissue from workers). This accords with the haploid number (n=26, testis) found by us for this species in Finland.

DLUSSKY (1967) considers *F. uralensis* a member of the subgenus *Serviformica*, but BETREM (1960) and KUTTER (1977) refer it to the subgenus *Formica*. The view of DLUSSKY (1967, and personal communication) is based on the fact that the mandibles of *uralensis* males are of the same supposedly primitive dentate type as in some *Serviformica*. Other features of *uralensis* diagnostic of *Serviformica* are the complete lack of outstanding hairs on the eyes of all the castes, including the males, the dullness of the frontal triangle on the head and possibly the narrowness of the parameres of the male genitalia (DLUSSKY, personal communication; see also KUTTER 1977). In the Finnish populations of *F. uralensis* the male mandibles are indeed of a markedly dentate type compared with those in *Formica* s.str. (in which

Table 1. Each row in the table corresponds to a nest. Column "No. nuclei" = the total number of haploid metaphase nuclei in which chromosomes were counted (the number within parenthesis is the number of nuclei with the most common chromosome number). Column "n" = the most common chromosome number

Species and nest	Locality	No. nuclei	n
F. (Formica) polyctena	Grankulla	68(65)	26
F. (Formica) aquilonia	Esbo	11(11)	26
F. (Formica) aquilonia	Vanda	37(37)	26
F. (Formica) lugubris	Vanda	22(22)	26
F. (Formica) "nylanderi"	Sibbo	28(28)	26
F. (Formica) pratensis	Grankulla	37(34)	26
F. (Formica) truncorum	Ingå	10(7)	26
F. (Formica) truncorum	Hitis	75(65)	28
F. (Formica?) uralensis	Vanda	102(86)	26
F. (Serviformica) rufibarbis	Lappvik	10(5)	27
F. (Serviformica) transkaucasica	Siikajärvi	14(13)	26
F. (Coptoformica) pressilabris	Sjundeå	17(13)	26

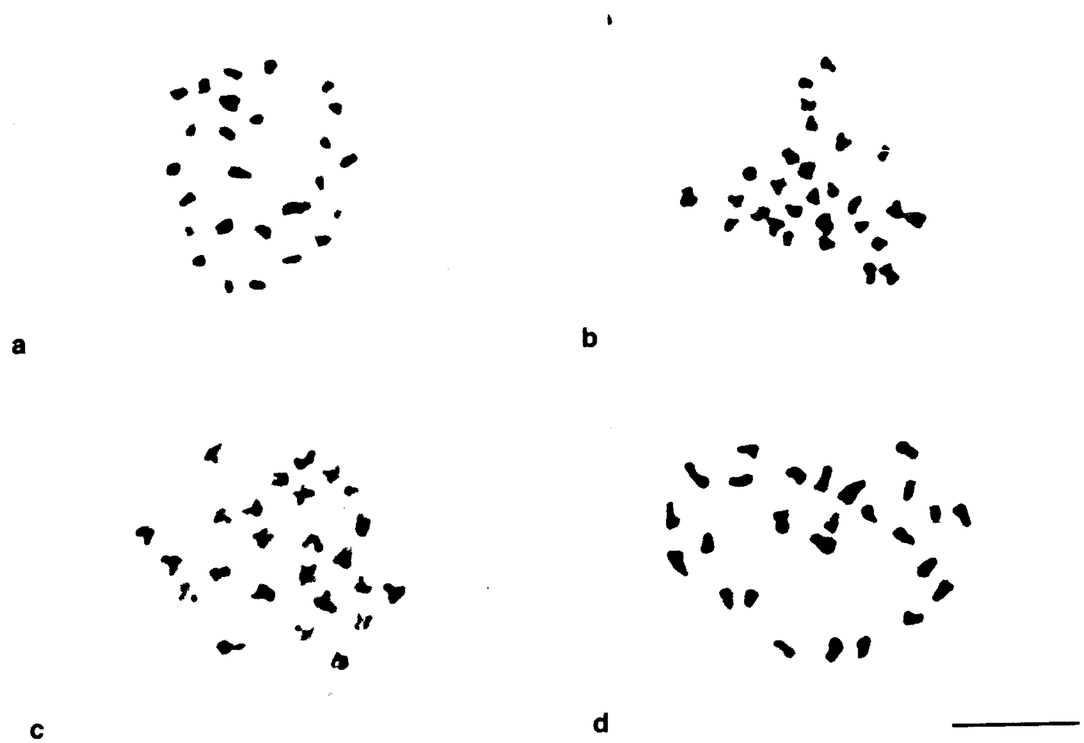

Fig. 1 a–d. Haploid chromosome sets of a: *F.* "*nylanderi*" n=26; b: *F. truncorum* (Hitis) n=28; c: *F. uralensis* n=26; d: *F. aquilonia* n=26. Bar: 10 μm.

all the teeth on the mandibles, except the apical one, are either absent or reduced to one or two irregular knots) and the workers are differentiated by the exceptionally strong sculpturing of the frontal triangle (Fig. 2). Arguments for not including *F. uralensis* in *Serviformica* are the facultative social parasitism of *uralensis* females during nest founding (KUTTER 1977), the structure and shape of the nest (mounds of needles as in the subgenus *Formica*) and the general type of foraging behaviour (ROSENGREN 1969, 1971). The chromosome number n=26 found in the present study also differs from the common pattern in *Serviformica*. There may thus be reason to consider that *Formica uralensis* represents a separate phylogenetic lineage, although its enzymes provide evidence of some relationship with *Serviformica* (PAMILO et al. 1979).

F. pressilabris Nyl. has the chromosome number n=26 (Table 1). This accords with results for *F. execta* reported from Switzerland (brains of workers, HAUSCHTECK-JUNGEN and JUNGEN 1976). The same chromosome number is found also in Nearctic *Coptoformica* (HUNG 1969).

HAUSCHTECK-JUNGEN and JUNGEN (1976) studied five species of the subgenus *Formica* (*rufa, polyctena, lugubris, truncorum* and *pratensis*) and found 2n=52 in all of them (brain tissue of workers). We have confirmed this result with testis preparations of *polyctena lugubris* and *pratensis* (n=26, Table 1) and in addition demonstrated that this number also holds for *F. aquilonia*. The same chromosome number is found in the *F.* "*nylanderi*" population, which, although showing affinities to *F. lugubris* in its worker morphology, has highly deviant queens and can possibly be separated as a new species (COLLINGWOOD 1979).

Some of the studied populations, e.g. *F.* "*nylanderi*" and *F. aquilonia* had a satellite chromosome (see Fig. 1.).

The number n=28 found for *F. truncorum* (Table 1, Fig. 1) is at variance both with the chromosome number of the other, more eastern *F. truncorum* population investigated by us in Finland and with the chromosome number (2n=52) reported for a Swiss population of this species by HAUSCHTECK-JUNGEN and JUNGEN (1976). We obtained the same result with male pupae (testes)

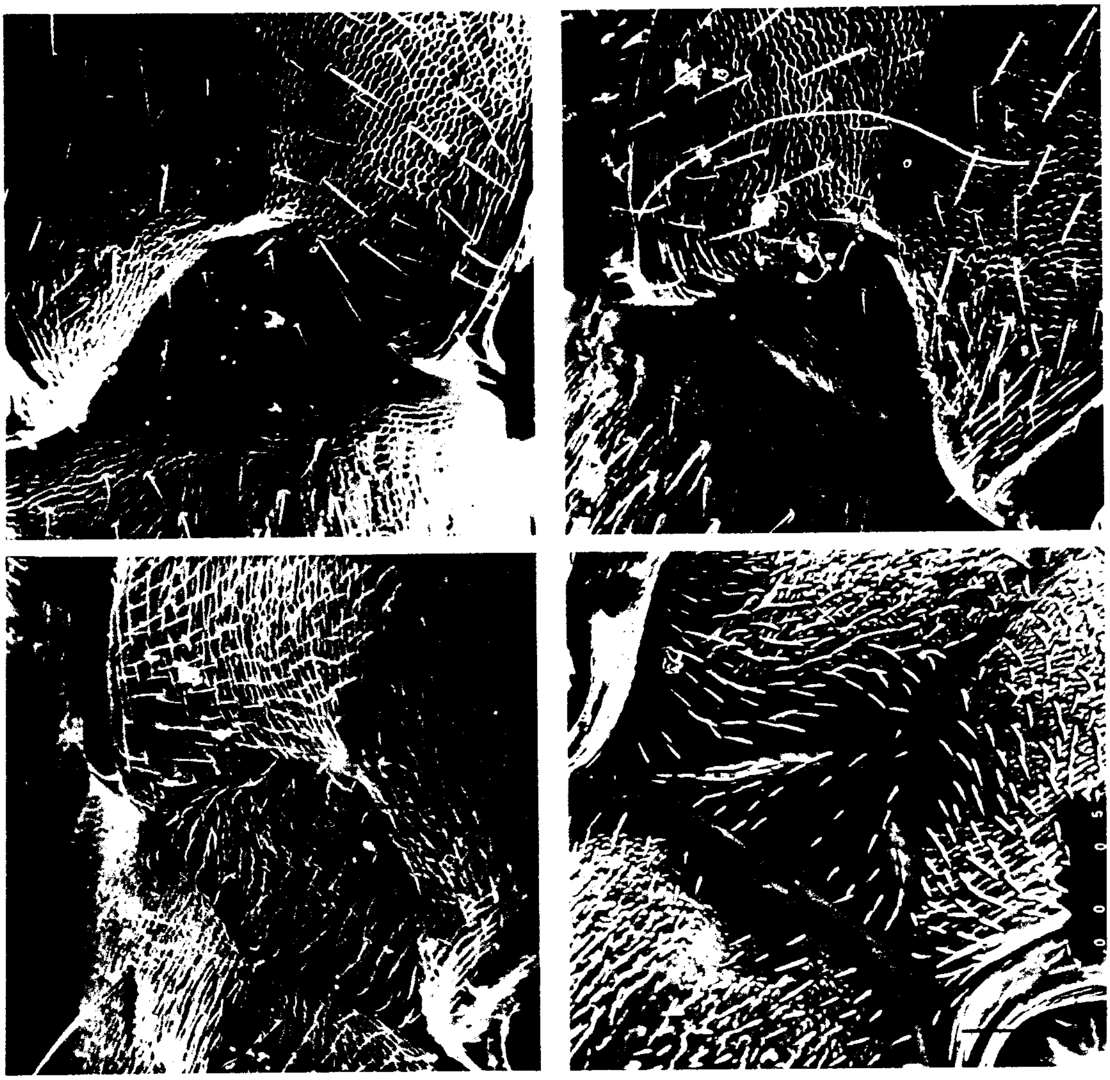

Fig. 2 a–d. Frontal triangle and adjacent parts on the heads of workers (SEM). a: *F. truncorum* (n=26), b. *F. truncorum* (n=28); c: *F. uralensis*; d: *F. aquilonia*. Bar: 100 μm.

from this nest in both 1978 and 1979 (results from the two years pooled in Table 1), but the material from 1978 contained one pupa with n=27 instead of n=28. Morphologically, the ants of this divergent population do not differ clearly from the normal (n=26) *truncorum* population. This was confirmed by our scanning electron micrographs. In both the Finnish *truncorum* populations the workers had a very characteristic chitin microstructure on the frontal part of the head (Fig. 2). According to our observations this type of microstructure is not found in any other species of the subgenus *Formica*, except *Formica yessensis* For. (specimens sent to us by Dr. Seigo Higashi from Sapporo, Japan). It is thus evident that *F. truncorum* has a very special position within the subgenus *Formica*, a fact also indicated by other features (KUTTER 1977; PAMILO et al. 1979). Our chromosomal findings can hardly be correlated with the taxonomic position of *truncorum*, unless n=28 is the rule in this species (which seems unlikely at present). Chromosomal polymorphism has been observed in several ant species, but has not previously been reported for the genus *Formi-*

ca, and the only chromosome numbers known ealier for *Formica* species are n=26 and 27.

Due to the smallness of the chromosomes and our failure to obtain a banding pattern, we were not able to determine what kind of chromosomal rearrangement had occurred to change the number from 26 to 28. Nor do we know whether only one or a few nests of *F. truncorum* are characterized by n=28, or whether we have to do with a karyotype "race" extending over a substantial part of the archipelago of the Gulf of Finland.

For the future, it seems important to develop banding methods suitable for the genus *Formica*, so that the chromosomes can be used more effectively to investigate the taxonomic relations.

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